Calibration of Magnetic Field Probes for the Muon-to-Electron Conversion Experiment

Toni Aubrecht (University of Southern California, Los Angeles, CA 90007), Michael Tartaglia (Fermi National Accelerator Laboratory, Batavia, IL 60510).

ABSTRACT

Accelerators and particle physics experiments rely heavily on magnet systems with specific magnetic field characteristics to focus and steer beams of charged particles. Accurate and precise measurements of these magnetic fields are crucial to ensuring the experiment correctly models the theoretical case. Before a field can be measured, the magnetic field probes must be calibrated by checking their outputs against a known field. By using a highly accurate nuclear magnetic resonance (NMR) probe as the standard for calibrations, various one-axis and three-axis Hall probes were calibrated using a GMW dipole magnet as the field source. Multiple LabVIEW programs were written to allow both the instruments and the data taking process to be run entirely from the computer. Six different data points — corresponding to six current levels for the magnet — were chosen based on the range of the NMR probe, which was 0.7–2.1 T. The exact field strength at these current levels was measured first using the main NMR probe and later verified using a second NMR probe. Each Hall probe was then inserted and aligned in the magnetic field to check the calibration of each axis separately. The two NMR probes agreed within 0.01% error. Calibration of the single axis Hall probes showed errors of less than 0.1%, while calibrations of the three axis probes gave errors ranging from 0.01–5.6%. The higher errors seen on the three-axis probes were determined to be due to the way a specific data acquisition card was reading the probe voltages. Once the digitizing instrument was switched to an older Keithley 2700 multiplexing voltmeter, the errors dropped well below the tolerance level of 0.1%. The probes showed no temperature dependence within 5 °C of 25 °C. One of the three axis probes is now being used to map the field of a large aperture helical solenoid magnet. A similar procedure is being applied to extend the calibrations of the 10 T range three-axis probe, using a Tevatron dipole magnet as the source of a highly uniform magnetic field, up to 5 T. The ability to measure very small field variations (0.01%) using this Hall probe is also being evaluated for future mapping of solenoid fields in the Mu2e experiment.